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LABORATORY INSTRUMENT SERVICES
CONTROL SYSTEMS DIVISION
THE RAMO-WOOLDRIDGE CORPORATION

ELECTRONICS FOR COMMUNICATION • MEASUREMENT • CONTROL

KAY LAB

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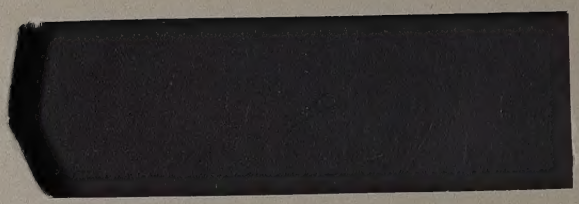

DC DECADE AMPLIFIER

MODEL 103

KAY LAB 5725 Kearney Villa Road San Diego 12, California

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SECTION 1

GENERAL

1.1 APPLICATION

The KAY LAB DC Decade Amplifier Model 103 contains a high gain, wide band, direct-coupled amplifier operated with negative feedback and frequency corrective networks to provide uniform response from DC through high AC frequencies in step-controlled gain of 0, 20, 40 and 60 db. The use of a chopper stabilized amplifier circuit produces essentially drift-free operation.

The KAY LAB DC Decade Amplifier is indispensable in many fields of electronics. Some typical uses are recorder or oscilloscope preamplification, strain gage measurements, servo system design and testing, geophysical and medical electronics, computer analysis and synthesis, and as a general purpose precision laboratory amplifier.

1.2 SPECIFICATIONS

Gain	0 db (1X), 20 db (10X), 40 db (100X), 60 db (1,000X), switched selected. All ranges are phase reversing from input to output.
Accuracy of Gain Setting	± 0.5 db at 1,000 cps.
Frequency Response for all Gain Settings	± 1 db DC to 25 kc, ± 3 db 25 to 100 kc, for output levels within the capabilities of the amplifier. (See below)
Input Impedance	Approximately 100,000 Ω shunted by 75 μμf.
Hum and Noise referred to INPUT Terminals	All ranges: 30 μv total, less than 15 μv due to components below 500 cycles.

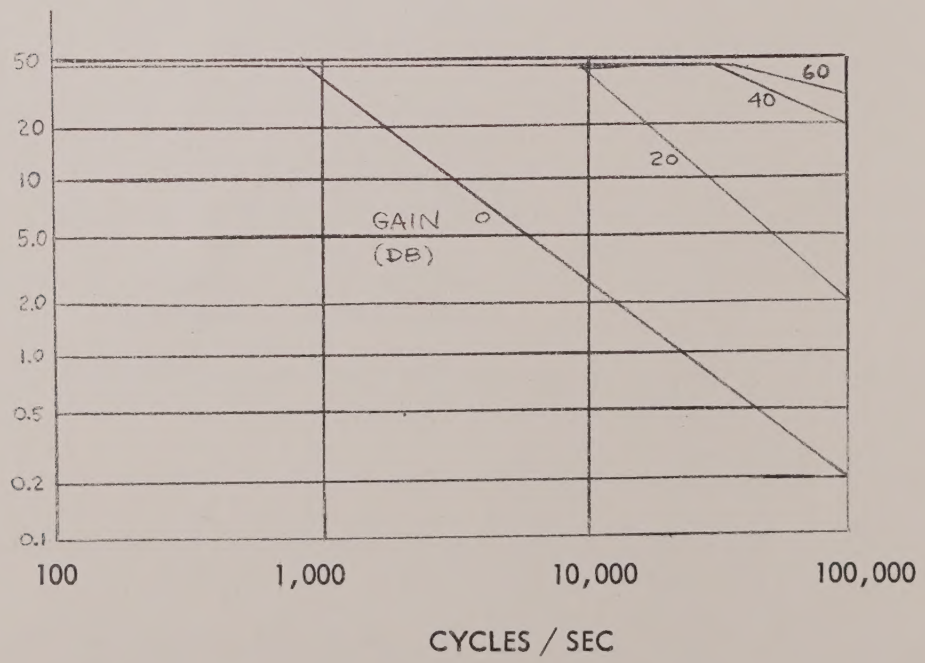
Notes:
1. All values are approximately RMS as read on a Hewlett-Packard 400C voltmeter with no bandpass filters.
2. Measured with amplifier INPUT terminals shorted.
3. Direct measurement of the noise on the 0 db range is not practical with an ordinary voltmeter.

Drift	After warm-up and balancing, long time drift does not exceed ± 10 μv equivalent input on any range for line voltages of 105 to 125 volts.

Note: Drift refers to a deviation in DC output level from that value determined by the DC input times the DC gain. For convenience it is referred to the INPUT terminals as an equivalent input error. It is most readily measured by shorting the input, adjusting the balance control for zero DC output, and observing the shift in the average or DC level vs time, ignoring the random fluctuations.

DC Output Resistance . . . . . Less than 0.05 Ω, all ranges
Minimum Load Impedance . . . . . 100 Ω
Rated Maximum Output Voltage . . . . . ± 35 volts DC or peak, open circuit. This is equivalent to 25 volts RMS for sine wave outputs within restrictions imposed by selected gain range and frequency. For stabilization certain internal networks must be changed with the range switch. These networks impose limitations upon the maximum output voltage vs frequency.

Typical performance for each range is shown below as a log-log plot of maximum RMS output vs frequency:



Maximum Rated Output Current	± 20 milliamps DC or peak. The product of load current and load impedance cannot exceed maximum voltage capabilities. Typically, the amplifier will deliver 20 ma RMS into 100 Ω up to 10 kc, and less at higher frequencies.
Input Power	105 to 125 volts, 60 cycles, approximately 150 watts
Weight	34 lbs.
Dimensions:	
Cabinet mount	17" wide, 9" high, 12 1/2" deep
Rack mount	19" wide, 9" high, 12 1/2" deep

1.3 WARRANTY

This instrument is warranted against defects in materials and workmanship for one year and will be repaired or adjusted free of charge at the factory (except for transportation costs) providing the adjustments have not been tampered with. Tubes are guaranteed for 90 days.

SECTION 2

CIRCUIT DESCRIPTION

2.1 THEORY OF THE SYSTEM

2.1.1 System Requirements.

The general requirements of the system as a whole are as follows:

1. Flat, stable response from DC to approximately 100 kc.
2. Net gain variable in 20 db steps from 0 to 60 db.
3. Equivalent input DC drift not greater than ± 10 μv.
4. Equivalent input hum and noise not greater than 25 μv RMS.
5. Output capability of ± 35 volts and ± 20 ma.

2.1.2 Block Diagram of the Basic System.

The basic system is shown in Figure 2.1. The amplifier is phase reversing with a gain of -K. This amplifier in practice may be composed of several amplifiers of various types as will be discussed later in detail. The feedback network consists of two impedances Z1 and Z2.

2.1.3

The basic equations governming the performance of the system may be derived as follows:

If the grid current, $i_3 = 0$, (1)

$$i_1 = i_2 \quad (2)$$

Assuming no offset when signal $E = 0$, $e_2 = 0$

By definition, $E = \frac{-e_2}{K}$ (3)

Inserting equivalent expressions in (1),

$$\frac{e_1 - E}{Z1} = \frac{E - e_2}{Z2} \quad (4)$$

Eliminating E by (3), rearranging (4), and solving for the ratio

$$\frac{e_2}{e_1} = -\frac{Z2}{Z1}\left[\frac{1}{1+\frac{1}{K}\left(1+\frac{Z2}{Z1}\right)}\right]$$

if $K \gg 1$, $\frac{e_2}{e_1} \simeq -\frac{Z2}{Z1}$

The resulting output impedance (z out) is the output impedance of the amplifier without feedback (Z_o) reduced by the net gain of the amplifier,

$$Z_{out} = \frac{Z_o}{K}\left[\frac{Z1 + Z2}{Z1}\right]$$

Input impedance.

if $e_1 \gg E$,

$$Z_{in} \cong Z1$$

2.2 THE SYSTEM OF AMPLIFIERS

2.2.1 The Chopper Amplifier

If the basic requirements are to be fulfilled, a system must be used in which there is little or no DC drift. This required that there must be no gried current flow into the summing junction. If such a grid current flow occurs, it will cause an apparent input signal. The chopper amplifier reduces grid current flow into the summing junction by use of the input coupling capacitor. Whereas in the direct coupled amplifier, grid currents in each stage would cause a DC offset, the chopper amplifier amplifies an AC signal which is proportional to the DC input and hence grid currents in the RC coupled stages do not cause a drift.

The conventional assumption of zero grid current when the control grid of a simple amplifier is biased negatively proves to be a falacy in this precision application. It is found that the grid current in a normal tube is sufficient to cause intolerable amounts of drift regardless of the amount of bias which is used.

The essential elements of the chopper amplifier used in Model 103 are shown in Figure 2.2. For simplicity, screen and bias circuits are not included. The amplifier consists of two high gain pentode stages with no net phase reversal between input and output. That is, when the input grid has a positive-going signal, the output plate also becomes more positive. Because of the RC coupling at the input and between stages, no appreciable grid current flows into the summing junction. In addition, DC drifts in the tubes cause no output voltage variation. The chopper is a double pole,

double throw type, driven at 60 cycles. One pole is used for input chopping, the other for output, so connected that the output capacitor (C2) is shorted to ground when the input grid is open, and vice versa. Under no-signal, equilibrium conditions, the input contacts do nothing. On alternate half cycles capacitor C2 is connected to ground, charging it to the static plate voltage of the output stage. Except for negligible leakage C2 remains charged to this voltage during the other half cycles when it has a path to the filter (R1-C3). Half of the time the input voltage to the filter is then zero, and during the other half it is equal to the plate voltage of the output stage, less the voltage drop in C2. With no input the drop in C2 equals the plate voltage, and no signal is applied to the filter.

Now assume that a positive DC signal is applied during the time the input contacts are closed. This signal is represented as a battery and current-limiting resistor. No signal reaches the amplifier, and the voltage on C2 is unchanged. This condition remains until the contacts switch. At this time the input grid and output plate go more positive. C2 now charges to the higher voltage while the input to the filter is shorted. At the end of this half cycle the input grid returns to normal, as does the output plate. However, the input to the filter is not zero, but sees the normal plate voltage of the output stage, less the drop in C2 which is now greater, resulting in a negative input. During the next half cycle the output plate voltage will again be higher than normal if the positive DC signal is still present. Had the input signal been negative, the output plate voltage would have been lower than normal during the charging period of C2. This would have caused a positive input to the filter in the same manner as before. In this system the output polarity (DC) is opposite the input polarity. This is due to the particular choice of chopper connections and number of stages. The function of the filter is to remove the ripple from output voltage.

2.2.2 The AC Amplifier

With a chopper amplifier sampling the DC and low frequency signals at 60 times per second, the requirement of flat gain to frequencies on the order of 100 kcs could not possibly be realized. An AC amplifier must therefore be incorporated into the system. This is accomplished as indicated in Figure 2.3. At the same time that the input signal is applied to the chopper amplifier, it is also applied through a capacitor to a single stage of AC amplification. The output of the AC amplifier is capacitively coupled to the input of the DC amplifier. The output of the chopper amplifier is directly coupled to the same input of the DC amplifier.

Coupling time constants of the AC amplifier and the chopper filter constants are so adjusted in value that a smooth cross-over in gain results.

A premium type low-noise pentode is used for this stage, making the 25 μv hum and noise specifications practical.

2.2.3 The DC Amplifier

The gain of the chopper amplifier is sufficient to take care of the requirements as to offset and drift.

After the signals have been sufficiently amplified, a conventional direct coupled DC amplifier is used. The drift and offset of the remaining stages of the DC amplifier are not sufficient to cause the requirements initially laid down to be violated.

The DC amplifier has two stages of gain and a cathode follower output, hence no net phase reversal. Thus, with either the AC or chopper amplifiers in series with the DC amplifier, the required overall phase reversal is accomplished.

2.2.4 The Feedback Network

The GAIN control functions in the following manner; as shown in paragraph 2.1.3, the ratio of the voltage e3/e1 = Z2/Z1. The values of the attenuator are so proportioned that the 100K loading caused by Z2, the ratio of the voltage is e2/e3 = 10 for the 20 db setting. The overall gain is then e2/e1 = e2/e3 x e3/e1 = e2/e3 x Z2/Z1 = e2/e3. The gain, therefore, depends only on the ratio of the resistors in the precision attenuator and is accurate to the accuracy of Z1, Z2, and the resistors of the attenuator. Variations in circuit parameters due to filament voltage and tube aging are of little consequence. Similarly, for the 40 db setting, with the loading caused by Z2 taken into consideration, the ratio e2/e3 is made equal to 100, and for the 60 db setting, e2/e3 is made equal to 1000.

2.3 DETAILED CIRCUITS RELATED TO SCHEMATIC

Now that the general theory of the amplifier system has been discussed, the various circuits as actually used will be pointed out on the schematic diagram given in the appendix.

2.3.1 The Chopper Amplifier

The chopper amplifier is located on one subchassis and consists of the chopper (C1101) and two pentodes (V1101 and V1102).

Observe the two feedback resistors Z1 and Z2 are two 100K resistors (R401 and R402). The low frequency and DC signals are fed through R1116 to the input chopper (pins 1, 3 and 2 of D1101). After two stages of capacitive coupling, the output of the chopper amplifier is taken from the junction of C1110 and R1113 and fed to the input of the DC amplifier (V1302). The signal at the output is chopped by the output pole pin 6 of D1101. The capacitor which is sampled for charge is C1108. The chopped output is filtered by C1110, R1117, R1114 and C1109.

2.3.2 The AC Amplifier

The input signal is fed through the input impedance Z1 (R401) and capacitively coupled through C1310 to the control grid of V1301, the AC amplifier. After one stage of AC amplification, the high frequency signals are capacitively coupled through C1303 to the input of the DC amplifier (V1302).

2.3.3 The DC Amplifier

The DC amplifier consists of two stages (V1302 and V1303) plus one cathode follower output stage (V1304). The DC and AC signals are then fed directly to the output from the cathode of V1304. The hot side of the output terminal will be observed to be connected to the top of the gain control (R407).

2.3.4 Feedback Network and Gain Switching

2.3.4.1 Gain Control: As previously explained, the gain is controlled by means of varying the feedback. Switch S402A and S402B is the main control for gain switching.

In the 0 db position, it will be observed that the output is fed back directly to the precision resistors R402 and R401, each being equal in value. Since Z2/Z1 equals 1, the gain is unity.

In the 20 db position, observe that R403 is placed in series with the feedback network so that now Z2/Z1 = 900 + 100/100 = 10, for a gain of 20 db.

In the 40 db position, the precision attenuator R407, R406, R405 and R408 is used with the gain stepped down to the first position below R407.

In the 60 db position of the switch, the gain is reduced by switching the feedback down to the junction of R405 and R406.

In the balance position, the gain is switched to approximately 80 db by feeding back a voltage from the junction of R405 and R408.

The only purpose of S402B is to switch in R403 on the 20 db position.

2.3.4.2 Stabilization Switching: Oscillation is always a problem in any multistage feedback amplifier system. Assuming negligible power supply impedance, the low frequency stability is governed by the selection of the input and output time constants of the AC amplifier and the filter on the chopper amplifier. These are not affected by the net gain and so remain fixed. In this amplifier fixed high frequency networks are used in the AC amplifier and the first stage of the DC amplifier. High frequency feedback is used around the individual stages. The switch (S402C) selects the compensation necessary to stabilize the amplifier for a particular gain setting.

2.3 4.3 DC Balance: For minimum off-set, the amplifier may need to be balanced occasionally. The fourth section of the switch, S402D, provides the balance circuit. When in position, the output is connected directly across a zero-center DC microammeter with multiplier. For this adjustment, the gain (S402A) is set at 80 db thereby reducing the feedback sufficiently that the balance adjustment will have an observable effect. To adjust the balance, the potentiometer R1319, located on the front panel, is adjusted for zero DC output.

2.4 REGULATED POWER SUPPLIES

Stable, low-noise operation cannot be achieved without using good power supplies. Both the positive and negative supplies are vacuum-tube regulated and inter-referenced to reduce drift. They are exceptionally free of ripple and fluctuations due to line bounce, and hence contribute to the low noise of the amplifier.

2.4.1 The Positive Regulated Supply

The circuit of the positive supply utilizes a full wave rectifier (V201), passing tube (V1502) and regulator tube (V1501). The control grid voltage of V1501 is determined by the voltage divider (R1506 and R1521) which is across the entire output of the positive and negative supply. Should the negative voltage produced by the negative supply decrease in absolute value, the control grid will rise positively thus increasing the current through V1501 and producing a more negative voltage at the control grid of the passing tube (V1502). This decreases the voltage output at the positive supply. Thus the balance point of the system tends to remain fixed, and DC off-set caused by changes in power supply voltage is minimized.

The positive regulated supply furnishes general B+ for all of the amplifier circuits.

2.4.2 The Negative Regulated Power Supply

V202, V1505, V1504 and V1506 comprise the negative power supply. The negative voltage produced is applied to the cathode circuit of the cathode follower output, and the control grid of the cathode follower and the driver amplifier are referenced to this point. Thus the amplifier system is capable of being balanced about ground with a dynamic range both above and below ground potential.

Bibliography:

John R. Ragazzini, Robert H. Randall and Frederick A. Russell, "Analysis of Problems in Dynamics by Electronic Circuits", Proceedings of the I.R.E., pp. 444-452, May, 1947.

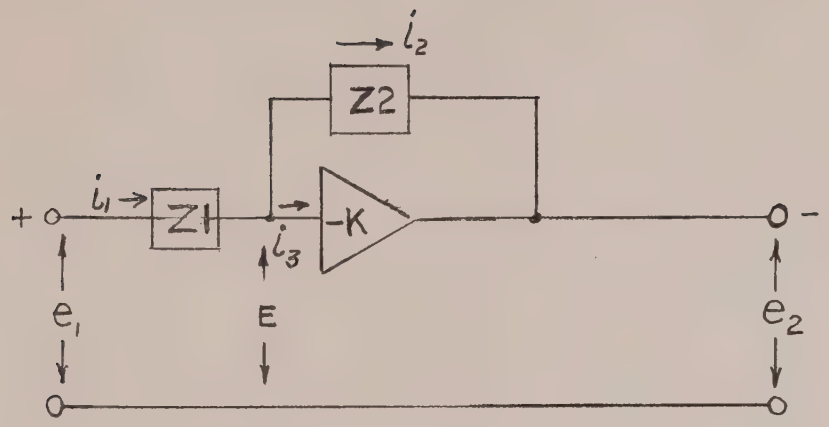


FIG 2.1

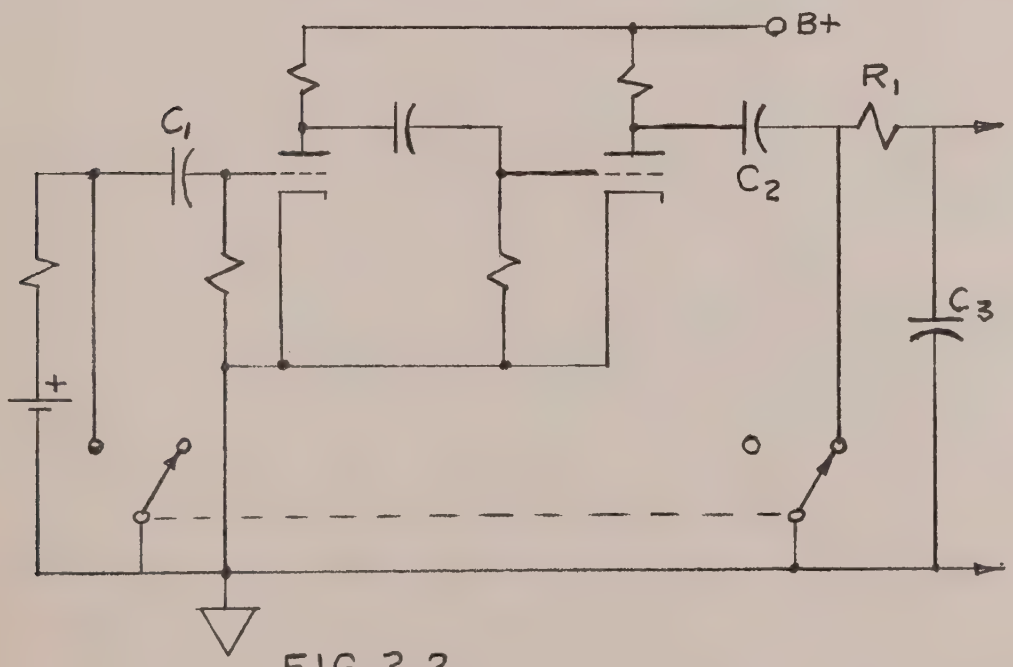


FIG 2.2

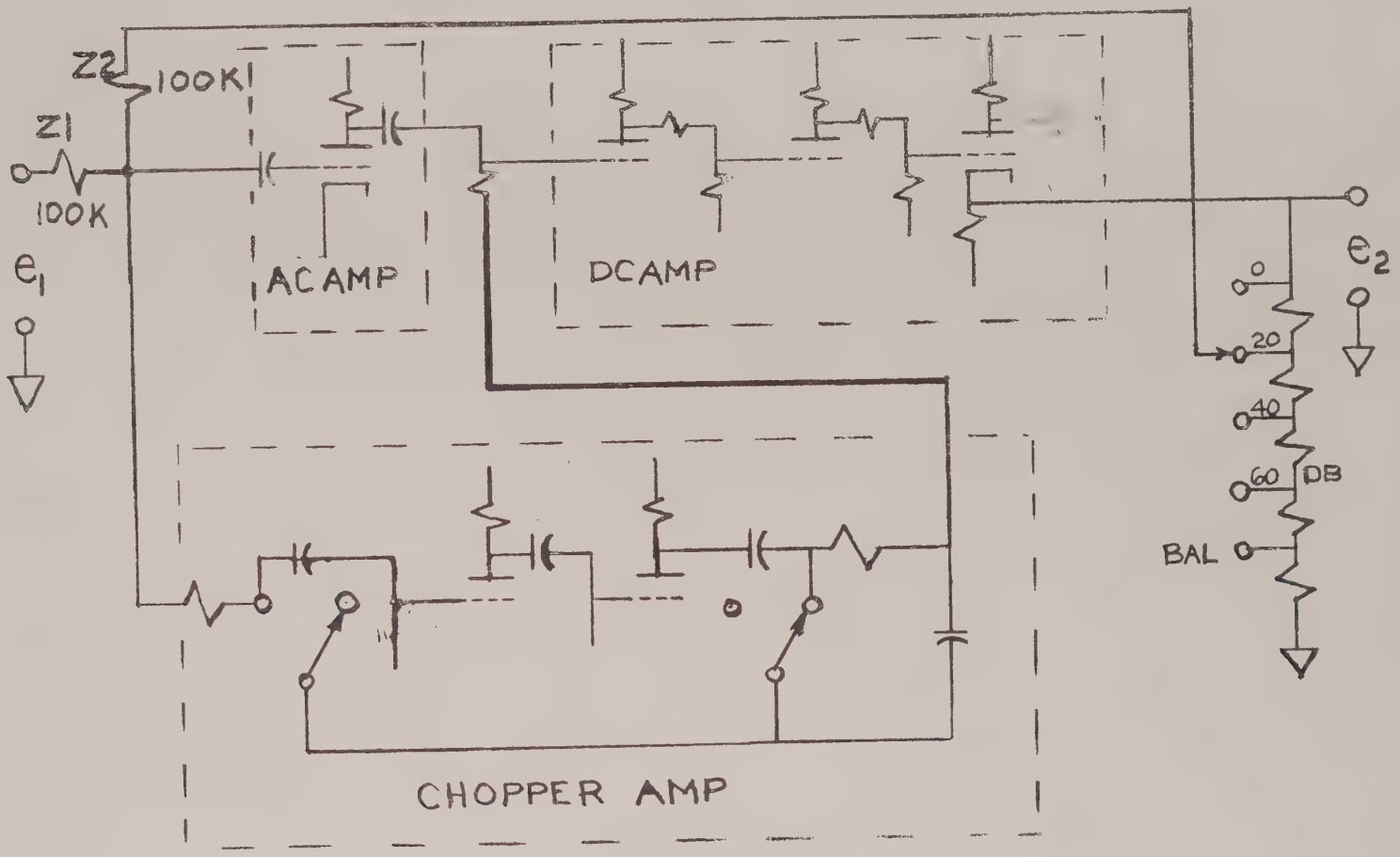


FIG 2-3

SECTION 3

OPERATING INSTRUCTIONS

3.1 UNPACKING

The DC Decade Amplifier Model 103 consists of one chassis. The unit is available in either cabinet style or 19-inch rack mount. The complete package is placed in a wood crate and suspended in wood-straw. When removing the packing material, carefully preserve any packing slip, invoice or special instructions which will normally be placed under the inside cover of the wood crate.

After receiving the instrument, remove the cover and all packing materials. Inspect carefully for loose tubes or any damage. Unless there is a broken amplifier tube necessitating replacement, the potentiometers on the chassis will not need to be readjusted.

3.2 OPERATION

Connect the instrument to a source of 105 to 125 volts, 60 cycles AC, 140 watts. Turn on the AC switch on the front panel. Allow 5 minutes for the instrument to warm up. Turn the switch on the front panel to "BAL" Allow sufficient time for the instrument to recover from switching transient and to stabilize as indicated by stabilization of the reading of the meter. Adjust the BALANCE control slowly to bring the meter to zero.

After the instrument has been in operation for 100 hours or more, re-check the balance if critical operation with low level signals is desired. Although the range of the balance control is not great, this control may be used to offset the output of the amplifier and thereby balance out the effect of small residual emf's in the input cables or circuit under test. To do this, remove signal voltage from test circuit but leave the cables connected to the amplifier. Readjust balance control for zero output.

SECTION 4

MAINTENANCE

4.1 PHYSICAL LOCATION

The physical location of the major parts is shown in the tube and parts placement diagram of the appendix. The chopper amplifier is located on the right. The unregulated rectifier circuits for both the positive and negative power supplies are in the center rear portion of the chassis. The regulator tubes for the positive and negative power supplies and the cathode follower are located on the right. The AC and DC amplifiers are located in the shielded box in the front central portion of the chassis together with the precision gain control resistors and switch and balance potentiometer.

4.2 HUM BALANCE ADJUSTMENT

Over long periods of time, or when tubes have been changed, the amplifier circuits may need to be balanced with respect to AC hum. To do this, an adjustment is provided on the subchassis on the right. The potentiometer (R1522), which is connected across the heater circuits adjusts the balance of the heaters with respect to ground.

To balance out the hum, connect an AC vacuum tube voltmeter across the output terminals, input terminals shorted. Set the gain at 60 db. Adjust the potentiometer (R1522) for zero output as indicated on the AC vacuum tube voltmeter.

4.3 HUM AND NOISE MEASUREMENT

To measure the total hum and noise, short the input terminals to the amplifier and connect an AC vacuum-tube voltmeter such as the Hewlett-Packard Model 400C, across the output. The total noise produced should be less than 30 microvolts total equivalent input noise. This means, for example, that on the 40 db (100X) gain setting, the output hum and noise should not be more than 3000 microvolts, as read on the meter connected to the output terminals. (See specifications, Section 1.)

If the observed noise is much greater than specifications, the instrument may require service.

4.4 TROUBLE SHOOTING

The following routine checks are recommended:

Check all tubes on a tube tester capable of measuring transconductance Compare the drop-off in transconductance for a given heater voltage drop with that experienced with a new tube Imminent failure of a tube will generally be preceeded by an inability to hold transconductance with subnormal heater voltage. The premium pentode (Z729) is especially critical. Replace this tube with one which is known to be in good condition if available. Replace the regulator tube (V1506).

Check the output of the regulated power supply. The total noise and bounce as observed on an oscilloscope should measure no more than 150 microvolts. If an unusually large noise or hum output from the regulated power supply is observed, check tubes and electrolytic capacitors of the regulated power supply. Other components of the power supply which are especially critical are the high frequency bypass capacitors (C1501, C1505, R1506, F1521, R1519, R1520).

Check voltages against values on schematic.

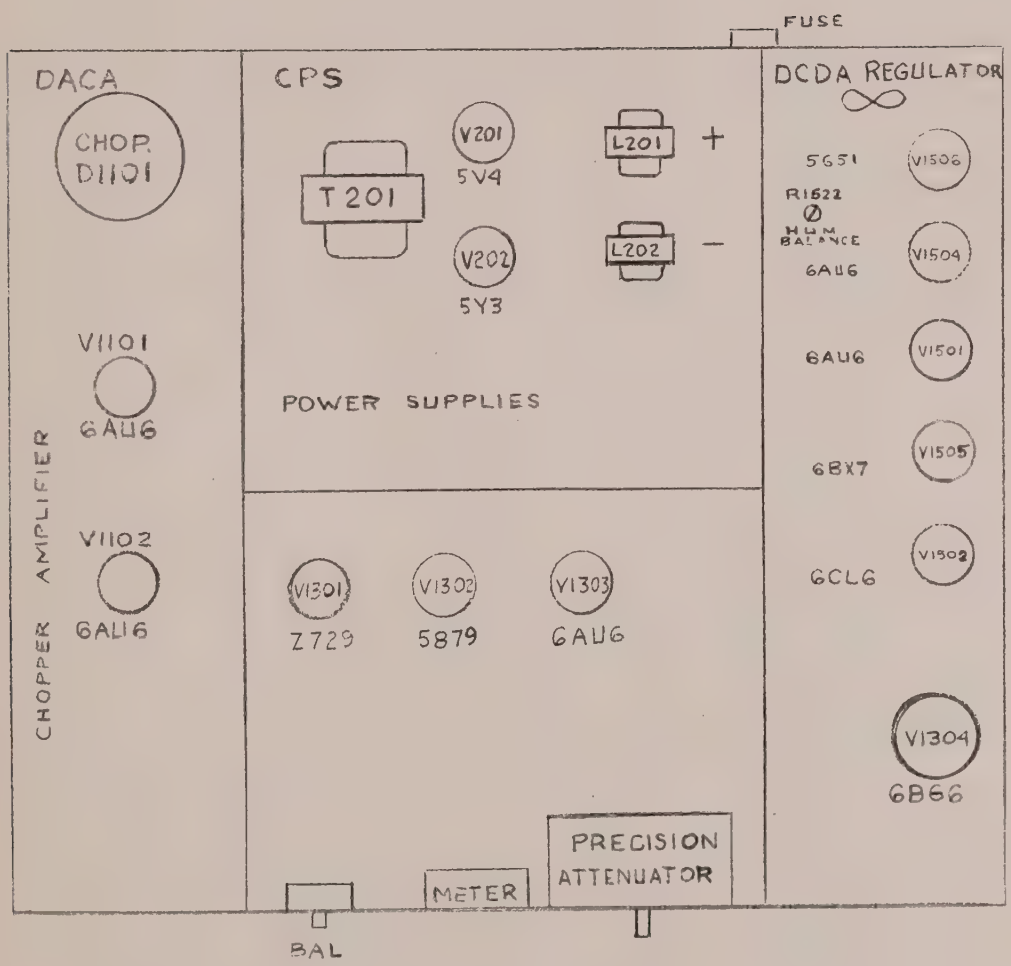
A noisy balance potentiometer is indicated when an accurate balance cannot be obtained on the meter.

After long periods of use, poor contact in the gain switch is a potential source of trouble.

Although the average life of a chopper is approximately 1000 hours, the chopper will often last for a much longer period of time. The life may be much less if the input has been subjected to severe overloads. The best test of a chopper is direct replacement. However, it is possible to detect a bad chopper in some cases by observing the waveforms produced. If an oscilloscope is connected at the output chopper between pin 7 and ground, the period when the chopper grounds this point will be indicated by zero output or a perfectly straight line for the oscilloscope trace. This is called the "dwell time". The dwell time should be about 45% of the total period. For 55% of the time, the contact between pins 6 and 7 will be broken and the oscilloscope will record a spurious response of transients. A bad chopper contact is usually indicated by a short dwell time, a typical bad chopper producing a dwell time of some 10% of the period.

It is possible to similarly check the input chopper by application of a DC signal at the input of 1.5 volts derived from a flashlight cell. An oscilloscope can then be connected from pin 3 to pin 2 of the chopper and a similar dwell time should be observed.

The fact that a chopper passes this test, however, does not guarantee that it is not faulty in some other respect.



DCDA MODEL 103

TUBE & PARTS PLACEMENT

PARTS LIST

MODEL 103

DCDA AMPLIFIER

		KAY LAB PART NO.
RESISTORS		
R1101	12 ohms 1/2w	411298
R1102	47K 2w	451801
R1103	20 ohms 2w C. T. Pot.	501884
R1104	68K 2w	451803
R1105	3.3K 1/2w	411327
R1107	1 meg 1/2w	411357
R1108	1.2 meg 1/2w	411358
R1109	3.3 meg 1/2w	411363
R1110	1 meg 1/2w	411357
R1111	1 meg 1/2w	411357
R1112	3.3 meg 1/2w	411363
R1113	56K 1/2w	411342
R1114	15 meg 1/2w	411371
R1116	8.2 meg 1/2w	411368
R1117	1.5 meg 1/2w	411359
CAPACITORS		
C1101	1 mfd 200V Goodall 620	66443
C1102	8 mfd 500V Elect. tube dry	51103
C1103	1 mfd 200V Metalite	61219
C1104	300 mmfd Ceramic Disc 500V	41032
C1105	.1 mfd 400V Paper	81248
C1106	.1 mfd 400V Paper	81248
C1107	300 mmfd Ceramic Disc 500V	41032
C1108	.005 mfd Ceramic Disc 500V	41054
C1109	1 mfd Metalite 200V	61219
C1110	.005 mfd Ceramic Disc 500V	41054
C1111	.005 mfd Ceramic Disc 500V	41054
MISCELLANEOUS		
BT1101	Bias Cell Mercury	184158

PARTS LIST

MODEL 103

DCDA AMPLIFIER

		KAY LAB PART NO.
RESISTORS		
R1301	6.8K 1/2 w	411331
R1302	10K 1w 10%	431563
R1303	100K 1 w	431575
R1304	27K 2 w 10%	451798
R1305	1 meg 1/2w	411357
R1307	100K 1w	431575
R1308	47K 2w 10%	451801
R1309	15K 1w	431565
R1311	1 meg 1/2w 1% Carbofilm	473481
R1312	3 meg 1/2w 1% Carbofilm	473516
R1313	56K 1w 10%	431572
R1314	22K 1w 10%	431567
R1315	22K 1w 10%	431567
R1316	1.72 meg 1/2w Carbofilm 1%	473498
R1317	3.75 meg 1/2w Carbofilm 1%	473519
R1318	10K 20w	512100
R1319	delete	
R1320	22 meg 1/2w 10%	411373
R1321	82K 1/2w	411344
CAPACITORS		
C1301	.01 mfd 500V Disc	41056
C1303	.1 mfd 600V Paper Mold	885113
C1305	.02 mfd 500V Disc Ceramic	41058
C1306	.02 mfd 500V Disc Ceramic	41058
C1310	1 mfd 200V Goodall 620	65300
C1312	10 mfd 150V Electro Tube	53744
MISCELLANEOUS		
Chassis	DCDA Amplifier	782119
BT1301	Mercury Cells RM 625T	184158
BT1302	Mercury Cells RM 625T	184158

PARTS LIST

CONTROL POWER SUPPLY
SUB-ASSEMBLY
(Job #122)

		KAY LAB PART NO.
CAPACITORS		
C201	40/40mfd 500V Electro Can w/Ins. Tubes	51144
C202	40/40mfd 500V Electro Can w/Ins. Tubes	51144
TUBES		
V201	5V4G	702723
V202	5Y3GT	702726
MISCELLANEOUS		
L201	Choke Triad #14372	673683
L202	Choke Triad #14372	673683
T201	Transformer Triad #7644	653651

PARTS LIST

MODEL 103

DCDA REGULATOR

RESISTORS

R1501	1 meg 1/2w 10%	411357
R1502	1K 1/2w	411321
R1303	390K 1/2w 10%	411352
R1504	39K 1/2w 10%	411340
R1505	470K 1/2w 10%	411353
R1506	270K 1/2w 1% Carbofilm	473456
R1507	51K 1/2w 5%	421463
R1510	1K 1/2w	411321
R1512	100K 1w 10%	431575
R1513	51K 1/2w 5%	421463
R1514	1 meg 1/2w 10%	411357
R1515	1K 1/2w	411321
R1516	390K 1/2w 10%	411352
R1517	100K 1/2w 10%	411345
R1518	270K 1w 10%	431580
R1519	475K 1/2w 1% Carbofilm	473466
R1520	190K 1/2w 1% Carbofilm	473453
R1521	400K 1/2w 1% Carbofilm	473463
R1522	100 ohm Pot. 2w	501890
R1523	1 meg 1/2w 10%	411357

CAPACITORS

C1501	.1 mfd 400V Paper Mold	81248
C1502	.25 mfd 400V Paper Mold	81250
C1503	300 mfd 500V Ceramic Disc	41032
C1504	.01 mfd 500V Ceramic Disc	41056
C1505	.1 mfd 400V Paper Mold	81248
C1506	.25 mfd 400V Paper Mold	81250
C1507	300 mfd 500V Ceramic Disc	41032

MISCELLANEOUS

Chassis	DCDA Regulator	782118

PARTS LIST

MODEL 103

FINAL ASSEMBLY

		KAY LAB PART NO.
RESISTORS		
R401	100K 1/2w 1%	473448
R402	100K 1/2w 1%	473448
R403	900K 1/2w 1%	473479
R404	6.8K 1w	431561
R405	100 ohm 1/2w 1%	473397
R406	1K 1/2w 1%	473403
R407	10K 1/2w 1%	473412
R408	10 ohm 1/2w 1%	475750
R409	18K 1/2w	411336
CAPACITORS		
C401	1.2 mmfd Ceramic	86521
C402	500 mmfd Ceramic Disc	41039
C403	250 mmfd Ceramic Disc	41030
C406	.002 mfd Ceramic Disc	41050
C407	10 mmfd 10% Ceramic	46188
TUBES		
V201	Tube 5V4	702723
V202	Tube 5Y3	702726
V1101	Tube 6AU6	702748
V1102	Tube 6AU6	702748
V1301	Tube Z729	705715
V1302	Tube 5879	733881
V1303	Tube 6AU6	702748
V1304	Tube 6BG6	702759
V1501	Tube 6AU6	702748
V1502	Tube 6CL6	702775
V1504	Tube 6AU6	702748
V1505	Tube 6BX7	702768
V1506	Tube 5651	732810

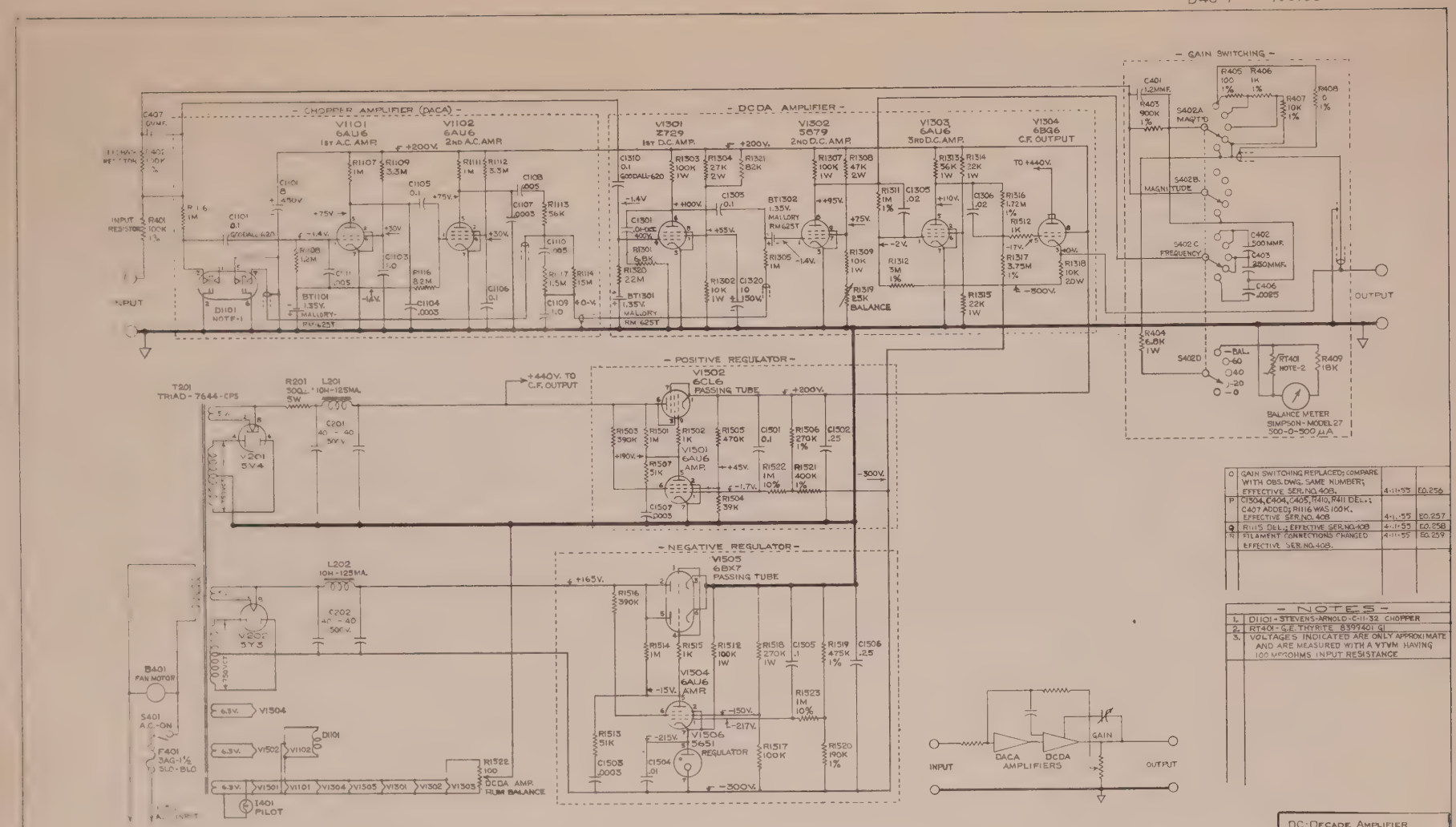
PARTS LIST

MODEL 103

FINAL ASSEMBLY

MISCELLANEOUS		KAY LAB PART NO.
S401	Switch Toggle SPST	613563
P121	Switch Index	626514
K Sect.	Switch Wafer U	626515
Chopper	C-11-32	633874
Knob	1-1/2" Skirted (2-set screw)	204184
Meter 500-0-500 micro-ampere Simpson # 27		304210
Line Cord 18-3		765034
Coax RG-62/U 3-ft.		766189
Fan Assembly		313838

D48-7 983906



O	GAIN SWITCHING REPLACED; COMPARE WITH OBS. DWG. SAME NUMBER; EFFECTIVE SER. NO. 408.	4-11-55	EO.256
P	C1304, C404, C405, R410, R411 DEL.; C407 ADDED; R1116 WAS 100K. EFFECTIVE SER. NO. 408	4-11-55	EO.257
Q	R1115 DEL.; EFFECTIVE SER. NO. 408	4-11-55	EO.258
R	FILAMENT CONNECTIONS CHANGED EFFECTIVE SER. NO. 408.	4-11-55	EO.259

- NOTES -

1. D1101 - STEVENS-ARNOLD-C-11-32 CHOPPER
2. RT401 - G.E. THYRITE 8399401 G1
3. VOLTAGES INDICATED ARE ONLY APPROXIMATE AND ARE MEASURED WITH A VTVM HAVING 100 MEGOHMS INPUT RESISTANCE

ALL RESISTORS ½ WATT, ALL RESISTANCES IN OHMS, ALL CAPACITANCES IN MICROFARADS UNLESS OTHERWISE SPECIFIED.

DC: DECADE AMPLIFIER
MODEL - 103

ENGINEER — W G R	DRAWN BY — N S Tyler
DATE — 4-11-55	CHECKED BY
SCALE —	DRAWING NO. D-983906

KAY LAB
5725 Kearney Villa Road, San Diego 12, Calif.

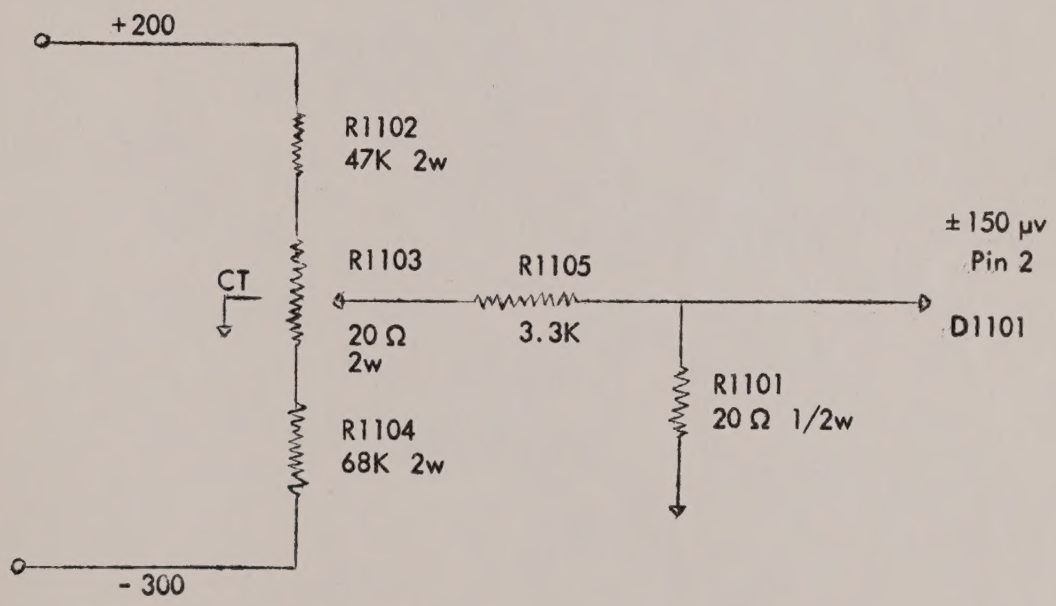
ERRATA
MODEL 103

DC DECADE AMPLIFIER

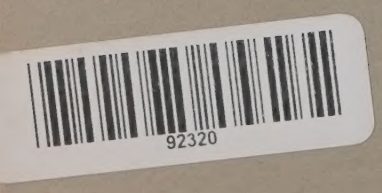
SCHEMATIC DRAWING D983906

Remove wire from bottom end of R1039 which went to Panel Control. Replace with a short wire to B- Common.

Remove Balance Control R1319, 25K. Replace with new circuit as follows:



KAY LAB
7-2-56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